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A GEOGRAPHIC INFORMATION SYSTEM IMPROVES AERIAL SKETCH MAPPING FOR THE SPRUCE BUDWORM

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A GEOGRAPHIC INFORMATION SYSTEM IMPROVES AERIAL SKETCH MAPPING FOR THE SPRUCE BUDWORM

by

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ABSTRACT

The Map Overlay and Statistical System (MOSS), a geographic information system, was used to produce a map of the Nicolet National Forest, Wisconsin, for aerial sketch map surveys. Stands susceptible to the eastern spruce budworm were located and color coded by stand density. The susceptible stands contained balsam fir, Abies balsamea (L.) Miller, and white spruce, Picea glauca (Moench), larger than 5 inches d.b.h. at a stocking greater than 39 percent. This map was used to assist in mapping damage caused by budworm.

INTRODUCTION

Aerial sketch mapping involves use of a low flying aircraft as a platform from which observers can visually detect and map forest damage. It permits rapid coverage of extensive forest areas and is one of the most economical detection methods available (Anonymous 1970, Klein et al. 1983). Although it is a practical detection tool, aerial sketch mapping as practiced now has a few disadvantages. The observers (1) tend to inaccurately estimate damage because it is difficult to accurately delineate damage boundaries; (2) may miss small areas of damage consisting of few or widely scattered trees; (3) are prone to include mixed host and nonhost type resulting in inflated estimates of damage; and (4) differ in accuracy depending on their sketch mapping experience (Waters et al. 1958; Harris and Dawson 1979; Heller 1978).

These disadvantages can be reduced by providing the aerial observers with better information on the location of timber stands susceptible to damage prior to the survey. With the recent advances in computer mapping technology,

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susceptible areas can be identified and located on a map using a geographic information system (GIS).

The eastern spruce budworm, Choristoneura fumiferana (Clemens), is a major pest of balsam fir, Abies balsamea, and white spruce, Picea glauca, in northern Wisconsin. A key component in the management of the budworm is knowing the distribution of defoliation and the resulting growth loss and/or mortality caused by this pest. The budworm's population fluctuates yearly (Royama 1984), requiring an annual aerial survey to record defoliation. After several years of intensive defoliation in the same areas tree mortality is also recorded. In 1984 GIS stand maps were produced to improve on damage assessments for eastern spruce budworm.

METHODS

The Nicolet National Forest in northeastern Wisconsin was selected as an aerial survey site. During previous surveys district personnel manually transferred the location of spruce and fir stands, that might be affected by spruce budworm feeding, from compartment maps to 1:126,720 scale National Forest type "A" maps. Such transfer of stands commonly misplaces some stands and coalesces others. Many transferred stands cannot be readily identified on the ground or assigned a specific identification number (Figure 1).

The Nicolet National Forest was selected because they already had a GIS in place.

The evaluation had two phases: (1) The production of a stand map using GIS (Figure 2); and (2) the use of these maps in the annual aerial sketch mapping survey for damage by spruce budworm on the Nicolet National Forest.

MAP PRODUCTION

A GIS is a computer system for handling input, storage, retrieval, manipulation and analysis, and reporting of spatial data (Marble 1984). The GIS used in this evaluation, the Map Overlay and Statistical System (MOSS), was developed by USDI Fish and Wildlife Service, Western Energy and Land Use Team (WELUT), located in Fort Collins, Colorado. MOSS is a flexible GIS with vector (polygon) and raster (cell) data capability (Reed 1979; Lee 1984) that is currently used on the Nicolet National Forest (Anonymous 1984). MOSS allows the user to select specified features from a map and overlay them on other map features. To date, more than 20 Nicolet National Forest thematic maps, or data themes, have been digitized for input into MOSS.

For this study, timber stand maps, which include wildlife openings, surface water features, roads, and town boundaries, were overlayed in MOSS. These latter data themes were included in the final map as aids for pilot and observer navigation.

Figure 1 - The standard USDA Forest Service one-half inch to the mile recreation map of the Nicolet National Forest, Wisconsin. This map was used in the 1983 aerial sketch mapping survey for spruce budworm. Note the lack of timber stand information and the poorly defined areas of budworm damage as compared with Figure 2.

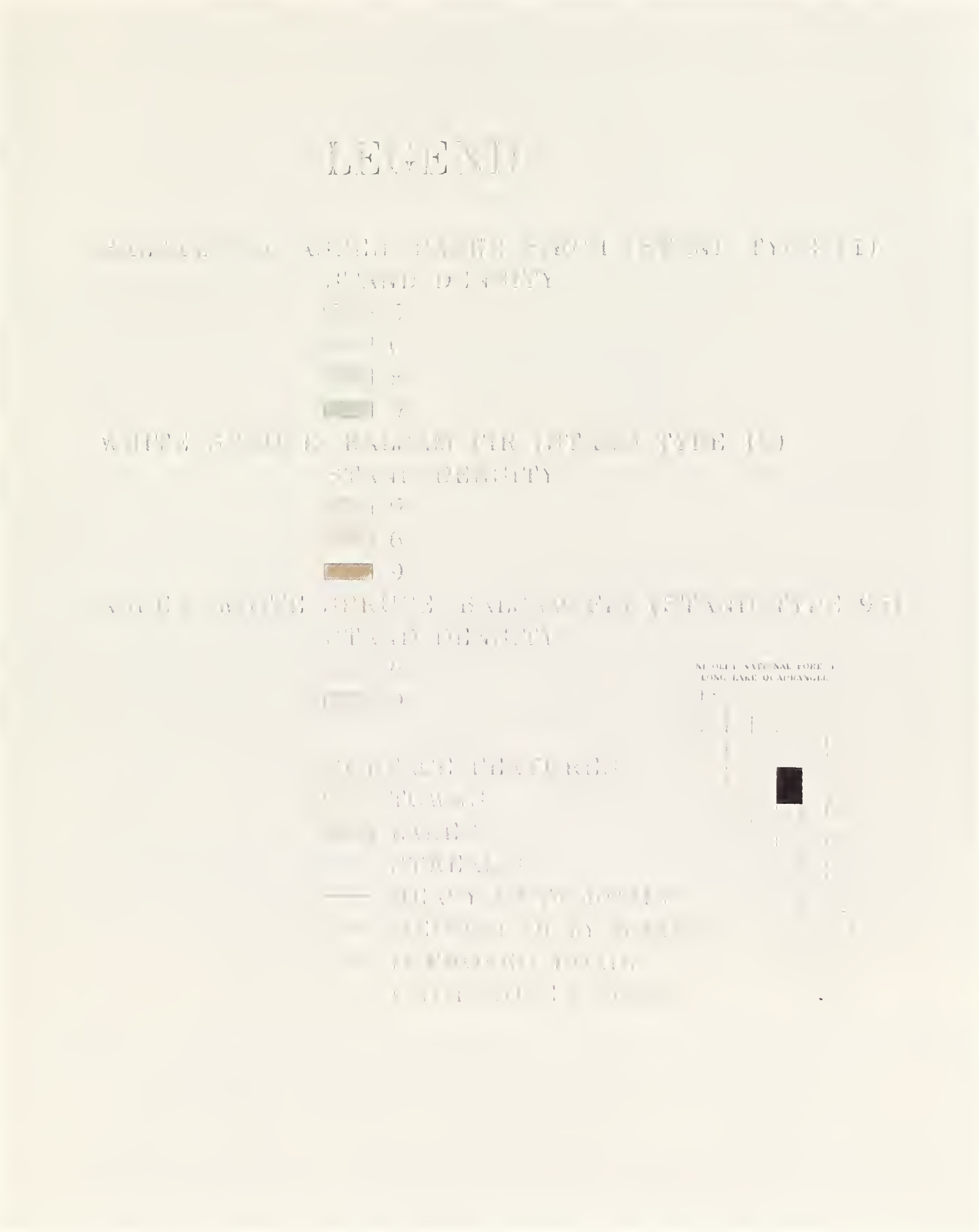

Figure 2 - Map of the Long Lake Quadrangle produced by the Geographic Information System, MOSS, for surveying spruce budworm damage on the Nicolet National Forest, Wisconsin. The susceptible stands are color coded for various species comparisons. The numbers (5, 6, 8, and 9) and related color shadings in the legend represent tree size class and density.

The timber stand theme is a complex map containing more than 30,000 stands managed by the forest. Stand attributes are encoded into MOSS using the same data structure found in the Timber Management Information System (TMIS), System 2000 database. The timber theme polygon attributes were sorted by MOSS, selecting only those stands susceptible to spruce budworm defoliation. Stands whose primary component was spruce and/or fir, or stands in which these species were considered to be economically important were selected. Other criteria were: (1) a minimum of 39 percent stocking density; (2) stands containing trees more than 5 inches (13 cm) dbh (diameter at breast height); and (3) stands more than 12 acres in size. The final map was printed using a Calcomp plotter [2] at a scale of 1:63,360 by WELUT personnel (Figure 2). The map of the entire forest was plotted in five separate east-west strips. This format facilitated handling during the survey.

AERIAL SKETCH MAPPING SURVEY

The aerial survey was conducted on July 26 and 27, 1984. A Cessna 172XP was used as the survey aircraft and flown at an altitude of 1,500 feet (460 meters) above ground at 75-85 miles per hour (120-140 kilometers hour). Preplanned east-west flight lines at 3 mile (4.8 kilometer) intervals were drawn on the five strips by the aerial survey observers. A Loran C navigation system and flight lines drawn on 0.5 inch to the mile (1.27 cm) National Forest Type 'A' maps were used by the pilot to insure flight line accuracy during the aerial survey. Areas of defoliation and mortality found in any stand were recorded directly onto the GIS map.

RESULTS AND DISCUSSION

A major advantage in using a GIS produced map instead of a forest recreation map was that tree stands were easily identified. This allowed the observer to focus attention on recording damage and not discriminating between individual tree species or between susceptible and nonsusceptible stands.

When using forest recreation maps to denote pest damage the boundaries may include large areas containing no damage and nonhost trees, especially when the damage area is irregularly shaped. A GIS produced map can help the observer delineate all forest stand boundaries or only those of particular interest; thus, mortality and/or defoliation can be ascertained for a single stand or several stands. This type of map gives a more accurate record and estimate of pest damage (Figure 2), which allows management of those individual stands rather than poorly defined areas. A GIS can also produce maps at various scales which increases efficiency when mapping pest damage. Previous aerial surveys conducted on the Nicolet National Forest have been limited to only two map scales.

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[2] Mention of commercial products is for convenience only and does not imply endorsement by USDA Forest Service.

Further evaluation of the information will require knowledge of the individual stand number. To have recorded the large number of different stand identification numbers on the map would have cluttered the map and reduced the map's readability. This lack of identification for the stands does create an additional step in interpretation, that of establishing the identification of those stands of interest.

Once the damage is recorded, the stand identification number can be obtained in the following way. The user can access the stand data theme at an interactive graphics terminal. The stand data theme is browsed to find a particular stand. The user then queries the data base to obtain that identification number. This interactive approach is most useful with small numbers (<20) of stands that need to be identified. Currently, new software is being developed to expediate the entire process.

After the identification number has been determined total acreage from these stands is calculated by MOSS using the area command (Table 1). The resultant map then becomes a permanent data theme in the forest GIS data base, e.g., 1984 spruce budworm defoliation survey.

Knowledge of the aircraft's current position is essential in locating stands and for general navigation. Therefore, any ground feature that can provide a point of reference should be included in the final map. Surface water features, such as secondary streams, swamps, and bogs, should be highlighted and distinguishable from the other objects. The judicial use of different colors and/or different line widths improves map readability.

The boundary of the Nicolet National Forest and its land ownership pattern are irregular, thus, the flight path commonly crossed nonfederally owned acres that had not been mapped in detail. A minimal amount of information, e.g., roads, water features, swamps, and bogs, would have helped in these areas for pilot and observer navigation.

CONCLUSIONS

GIS generated maps with all stand boundaries delineated were a significant asset to the aerial sketch mapping survey.

As an aerial survey tool, a GIS produced map offers flexibility and precision in aerial sketch mapping. Host types can be distinguished and affected acreage can be accurately calculated when surveying for a particular pest. The lack of observable spruce budworm defoliation did not detract from the objective of this survey.

We anticipate that future sketch mapping surveys for spruce budworm and other pests will be conducted with the aid of a GIS. The results from these damage surveys will be entered into the GIS as a separate pest damage theme. This new theme can be used with other GIS derived data to provide additional information for forest planning (Daniel et al. 1983). The map of damaged

Table 1: Area summary for stands susceptible to spruce budworm on the Nicolet National Forest, Wisconsin. This information was obtained directly from the Map Overlay and Statistical System (MOSS).

Timber Stand Type	Stand Size Class and Stocking Density		Area (Ac)
	Working Definition	GIS-ID	
Balsam Fir-Aspen-Paper Birch	Poletimber (40-69%)	(5)	4,127
Balsam Fir-Aspen-Paper Birch	Poletimber (over 70%)	(6)	20,169
Balsam Fir-Aspen-Paper Birch	Sawtimber (40-69%)	(8)	38
Balsam Fir-Aspen-Paper Birch	Sawtimber (over 70%)	(9)	1,646
White Spruce-Balsam Fir-Norway Spruce	Poletimber (40-69%)	(5)	128
White Spruce-Balsam Fir-Norway Spruce	Poletimber (over 70%)	(6)	5,487
White Spruce-Balsam Fir-Norway Spruce	Sawtimber (over 70%)	(9)	216
Aspen-White Spruce-Balsam Fir	Poletimber (70%)	(6)	3,126
Aspen-White Spruce-Balsam Fir	Sawtimber (over 70%)	(9)	1,726
	Total acres in 1974 stands		36,663

stands also provides information that can be used as a historical reference of pest activity. In addition, the damage themes, along with other themes pertinent to pest behavior, e.g., soils, topography, host type, can be combined using GIS to predict the most probable locations of pest activity and salvagable harvest areas. A GIS is and will continue to be an extremely useful tool for forest pest management activities.

The authors investigated the feasibility of using GIS generated maps for pest damage surveys. The accuracy and comparative costs for this technique could only be ascertained if both map types were compared directly in the same survey. Such comparisons should wait until GIS technology has been adopted as a fully operational tool in the Forest Service, and not as a tool that is being evaluated.

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